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RIBER Compact 21: the World Best Seller Molecular Beam Epitaxy System

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Molecular beam epitaxy is a sophisticated, finely controlled method for growing single-crystal epitaxial film in high vacuum (10^{-11} Torr). The films are formed by slowly evaporating materials on single-crystal held at a temperature appropriate for chemical reaction, epitaxy, and re-evaporation of excess reactants. The MBE has experienced extremely rapid growth over the past years on various applications (electronics, opto-electronics, ferromagnetics...) and is still recognized as the major technique for growing state-of-the-art devices.

1. Introduction

RIBER S.A. is the leading supplier of molecular beam epitaxy (MBE) products and related services for the compound semiconductor industry. We deliver MBE machines worldwide to major Universities, Material Science Institutes, Compound Semiconductor foundries or epiwafer merchant suppliers. RIBER moved towards molecular beam epitaxy in 1977, and has developed ever since a large range of MBE research, production tools, MBE components and processes in order to follow a growing stringent demand.

By acquiring ADDON (expert in MBE components) and Oxford Instruments Plasma Technology Ltd (MBE systems), RIBER becomes indisputably the world leader of MBE systems, with 75% of the worldwide installed base.

2. The Compact 21 system: world best seller R&D MBE system

The Compact 21 is the Riber baseline research MBE system (Fig. 1). It has been developed within the frame of the European Community project Brite-Eutam III Aniset and results of years of close cooperation with major scientific partners involved in molecular beam epitaxy of III–Vs and nitrogen-containing compound semiconductor materials.

The Compact 21 is a flexible and affordable MBE system with features carefully designed to meet the most demanding specifications of materials research and pilot production.

Based on waferfab-proven "MBE49 platform" technology, the Compact 21 provides, within a very small footprint, all the necessary MBE tools and *in situ* characterization capabilities to grow high quality compound semiconductor materials such as III–Vs, GaN, MCT etc.

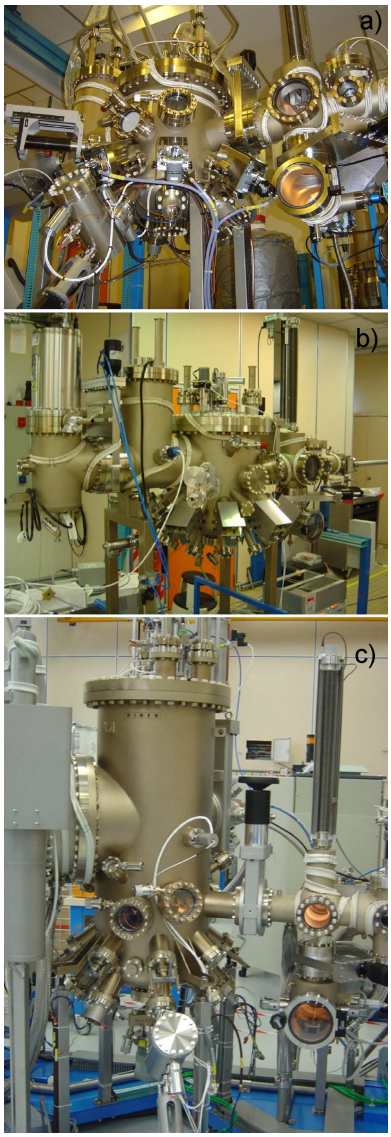

Fig. 1. (a) Compact 21 III-V. (b) Compact 21 II-VI. (c) Compact 21 HeM.

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2.1. Technical characteristics

The Compact 21T consists of 3 modules (Fig. 2):

- The MBE system.
- The MBE sources.
- The MBE process control system.

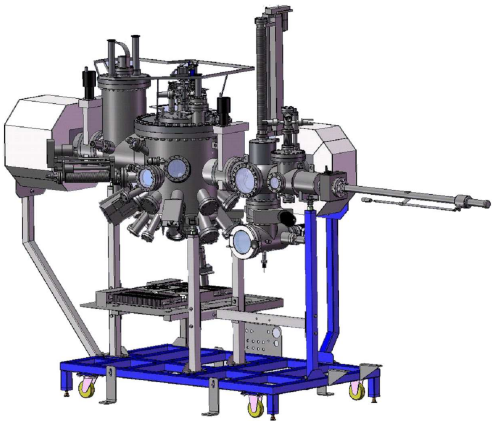

Fig. 2. Compact 21T system.

2.1.1. MBE system

It consists of (Fig. 3):

- The growth chamber.
- The pumping system.
- The wafer handling system.

The wafer handling system is where everything starts. Thanks to a fast door and a wooble stick, you can easily load the six positions cassette with your substrates. After pumping down with its dedicated oil-free turbopump, you can transfer this cassette in the buffer chamber with the lift.

The buffer/preparation chamber is the intermediate step before epitaxy. It is a complete, independent chamber with its own control and pumping system (ion pump 200 l/s, $< 5.10^{-10}$ Torr). It is used to store (2 positions resident cassette) and to prepare wafers prior to growth (up to 800°C outgassing station).

The substrates are transferred to the growth chamber thanks to a manual "pick and place" transfer rod.

The growth chamber is the heart of the system. It is a vertical UHV reactor with the wafer facing down: this design eliminates any source of contamination during growth.

The effusion cell/wafer evaporation has been optimized to reach high level of layer performances for the thickness, composition and doping uniformity.

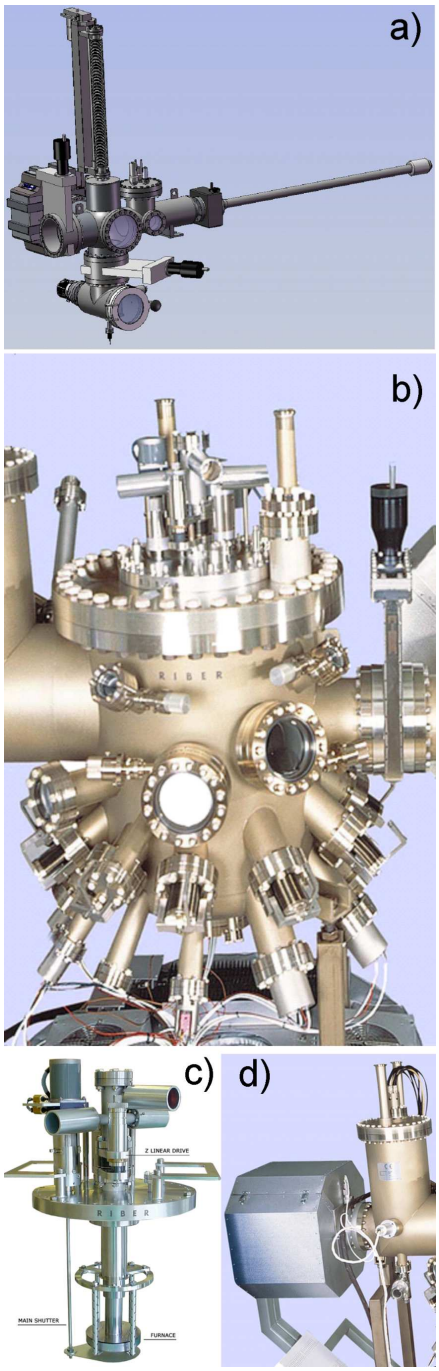

Fig. 3. (a) The wafer handling system. (b) The growth chamber. (c) The platen manipulator. (d) The pumping assembly.

Clean and high vacuum inside the growth chamber is mainly affected by a large-area liquid nitrogen (LN_2) cryopanel. It surrounds the entire deposition volume including the cells, ensuring that wafers only see cold stainless-steel parts.

The growth chamber includes ten cell ports with separated rocking shutters as well as all necessary ports to mount the MBE accessories and *in situ* characterization

tools (Rheed, RGA etc.). The cell ports face the platen manipulator at the same angle and distance, and are symmetrically distributed around the vessel.

The platen manipulator permits placement on one single wafer (up to 3"). It is capable of continuous rotation (up to 60 rpm) while heating up to 1100°C with a flat stable temperature profile across the wafer.

The pumping assembly is connected to the growth chamber by a 250 mm inside diameter (ID) nipple. Basic pumping is achieved using a 400 l/s ion pump. In the center of the nipple, a six-filament titanium sublimator with its dedicated LN_2 cryopanel is provided. Additional port is provided for mounting an additional pump (cryopump, turbopump). The ultimate pressure reachable is under 5×10^{-11} Torr.

2.1.2. MBE sources

The growth chamber has been designed for use with solid, gas, or special sources. The vertical geometry allows getting a maximum source capacity, even for liquid material. All the cells are mounted at the exact same angle to the normal of the wafer and they all converged to the center of the wafer. Separations are attached to the cryopanel in order to avoid cross contamination between cells. Each cell has its own separate rocking shutter electrically driven.

Several types of MBE sources can be mounted on the Compact 21 system:

- Arsenic and phosphorous valved crackers.
- 60 cc or 80 cc range effusion cells.
- Low capacity effusion cells for *n*- and *p*-type doping.
- RF plasma source.
- Gas injectors.

2.1.3. MBE process control system

Riber's Crystal is a powerful MBE process control software carefully designed for the supervision of MBE systems. It provides continuous precise information during the entire epitaxy process, from equipment configuration to growth data acquisition and storage.

The Crystal software enables:

- Control of effusion cells, crackers, shutters, gas injectors, platen manipulator, flux gauge, etc.
- Monitoring of proportional-integral-derivative (PID), pressure and flux gauge, *in situ* instrumentation, etc.
- Data management of MBE machine, installed equipment, growth recipe editor, and report editor, etc.

3.2. Compact 21: an expandable solution

Several stand alone Compact 21 can be connected together through (Fig. 4):

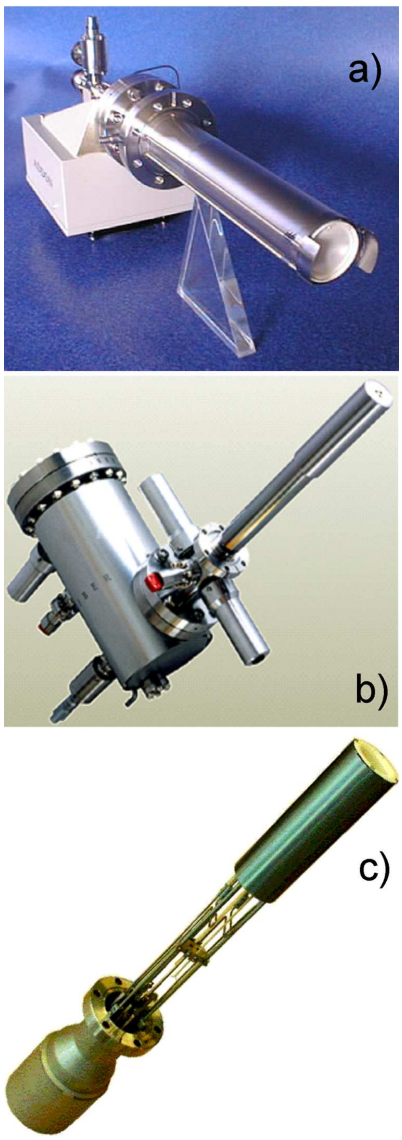

Fig. 4. (a) RF Plasma source. (b) Valved cracker. (c) Effusion cell.

Tunnel transfer: 100% manual, no limitation in number of chambers which can be connected together and tuneable with outgassing station and other equipment, this transfer system is a field proven solution with plenty of systems installed.

Cluster tool: the state-of-the-art innovation, semi-automatic or fully automatic, small footprint, compatible with up to three MBE chambers, plus additional loading/unloading, preparation and storage chamber. Riber is today the only company in the world to have a 3" cluster tool working on the field.

4. Summary

With more than 60 systems installed worldwide, Riber Compact 21 system is recognized by the MBE community

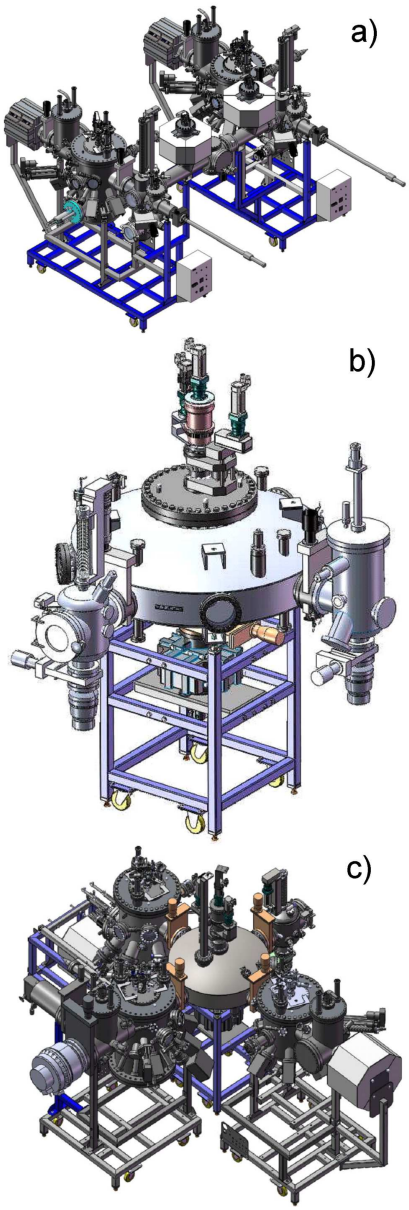

Fig. 5. (a) Tunel transfer. (b),(c) Cluster tool.

as the best R&D epitaxy system of its generation. With the Compact 21, we are providing you:

- Flexible $2''/3''$ system.
- Suitable for all type of epitaxial growth.
- Low cost of equipment ownership.
- Six to eleven sources ports.
- Wide range of element specific MBE sources.
- Specific ports for *in situ* characterization tools.
- User-friendly manual wafer handling system.
- Expandable through add-on options.
- Ease of use and maintenance.
- Riber worldwide support.